Measurement of Rare $\omega \rightarrow \eta\gamma$ Radiative Decay*

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The radiative decays of vector and pseudoscalar mesons are useful tests of the simple quark model and its extensions. In the family of the eleven vector meson to pseudoscalar meson decays, the decay of ω into to $\eta\gamma$ is one of the least well measured because of its very small branching ratio into neutral final states.

The Crystal Barrel Experiment (PS197) at Cern, Geneva, Switzerland, was used to measure the annihilations of an antiproton beam on a proton target. The nearly 4π solid angle coverage of the decay allows full event reconstruction from all of the final γ rays. The annihilation channel of $\eta\omega$ has used to produce decays of ω into the reference channel $\pi^0\gamma$ and into the rare channel $\eta\gamma$ (where $\pi^0 \rightarrow \gamma\gamma$ and $\eta \rightarrow \gamma\gamma$). Thus the intermediate states were $\eta\pi^0\gamma$ and $\eta\eta\gamma$ respectively, which end up finally as five γ states. Nearly 20 million neutral annihilations, triggered by an incoming antiproton and a veto from the tracking chamber, were used the analysis.

The dominant source of background was feed-through from six γ final states, where a soft γ's is lost in the detection or reconstruction process, resulting in a five γ final state. The respective backgrounds of $\eta\pi^0\gamma$ and $\eta\eta\gamma$ were therefore $\eta\pi^0\pi^0$ and $\eta\eta\pi^0$, where the soft γ is due to the last π^0. The $\eta\eta\pi^0$ channel's production rate is several orders of magnitude higher than that of $\eta(\omega \rightarrow \eta\gamma)$, so even a small percentage of feed-through causes a large background.

Extensive Monte Carlo simulations of all of the signal and background event channels were produced using the GEANT package.

The γ reconstruction for each event was repeated twice. The first reconstruction used a high energy threshold to discard low energy noisy signals to enhance the desired channels. The second reconstruction used a low energy threshold to look for the soft γ present in the background channels.

The first cuts on the data and simulated data selected 5 γ states, with each γ having a minimum energy of 20 MeV, which passed a 4C fit to total momentum and energy conservation. This selected data was reprocessed from the original measured signals, but this time with a 4 MeV minimum γ energy. The γ's were paired to form π^0 and η; any event with more than 1 π^0 or with having $\eta\eta\pi^0$ were discarded. The γ's from the 20 MeV reconstruction were used in the further analysis.

The 5 γ events were kinematically fitted to $\eta\pi^0\gamma$ and $\eta\eta\gamma$ hypotheses and separated into two groups, where ambiguous or bad events were discarded. From each group, a Dalitz plot of $\eta\gamma$ vs. $\pi^0\gamma$ and $\eta\gamma$ vs. $\eta\gamma$, respectively, was made. The real data and simulated data were treated to the same analysis chain, and in the end the real data was fitted bin by bin to a sum of the appropriate simulated data. 65K events of $\omega \rightarrow \pi^0\gamma$ and 150 events of $\omega \rightarrow \eta\gamma$ were identified in the fit.

Using tabulated values for all branching ratios except the rare channel, the branching ratio for the rare channel was measured,

$$\mathrm{BR}(\omega \rightarrow \eta\gamma) = (6.2 \pm 0.7 \pm 1.0) \times 10^{-4}.$$

where the first error is statistical and the second is systematic. This improves the errors of the previous tabulated value by 20%.

Footnotes and References

*Ph.D. Thesis of Mark Lakata, to be published.